CNTT-E-150

BASIC ELECTRICITY AND ELECTRONICS

STUDENT HANDOUT NO. 313

SUMMARY, PROGRESS CHECK FOR MODULE 34-2

JUNE 1984

SUMMARY
LESSON 2

IC Operational Amplifiers

An IC Operational Amplifier (opamp) is a class "A" amplifier which has two inputs and one output. One of the inputs will have the signal we wish to amplify applied to it. The other input will be connected to a resistor that will develop bias for the IC. The resulting output will be the input multiplied by the gain of the circuit.

Various schematic symbols for an IC opamp are shown in Figure 1.

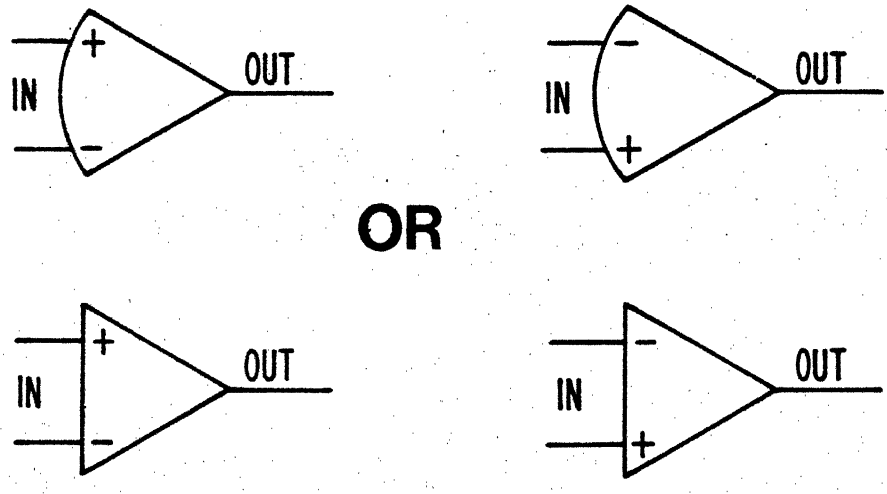


Figure 1

OPAMP SCHEMATIC SYMBOLS

IC opamps are used as either inverting or non-inverting amplifiers. Figure 2 shows an inverting IC opamp amplifier circuit.

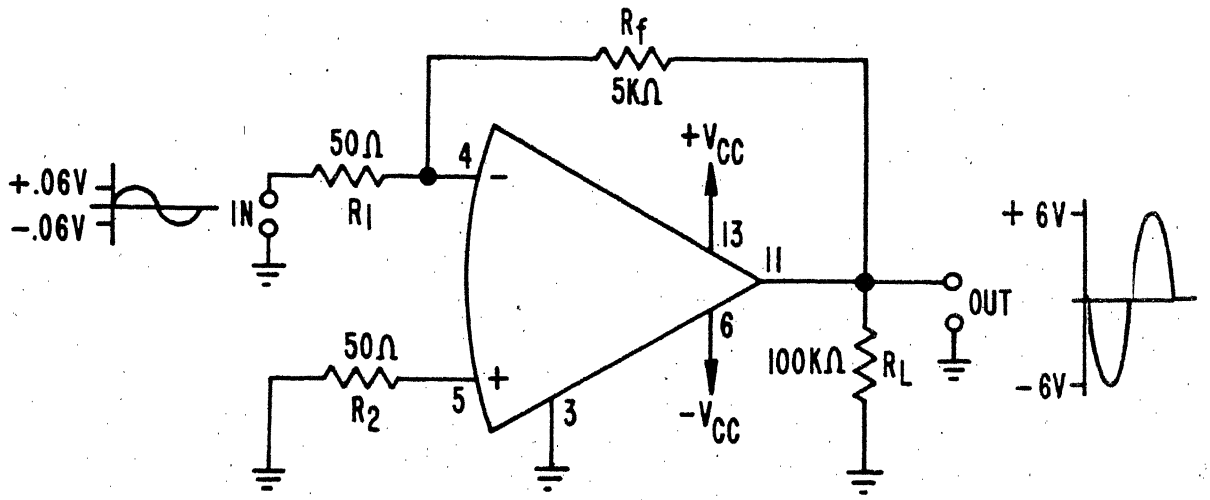


Figure 2

INVERTING OPAMP

In Figure 2, R1 is the input resistor, R2 the bias resistor, Rf the feedback resistor and RL the load resistor. Figure 3 shows a non-inverting IC opamp amplifier circuit.

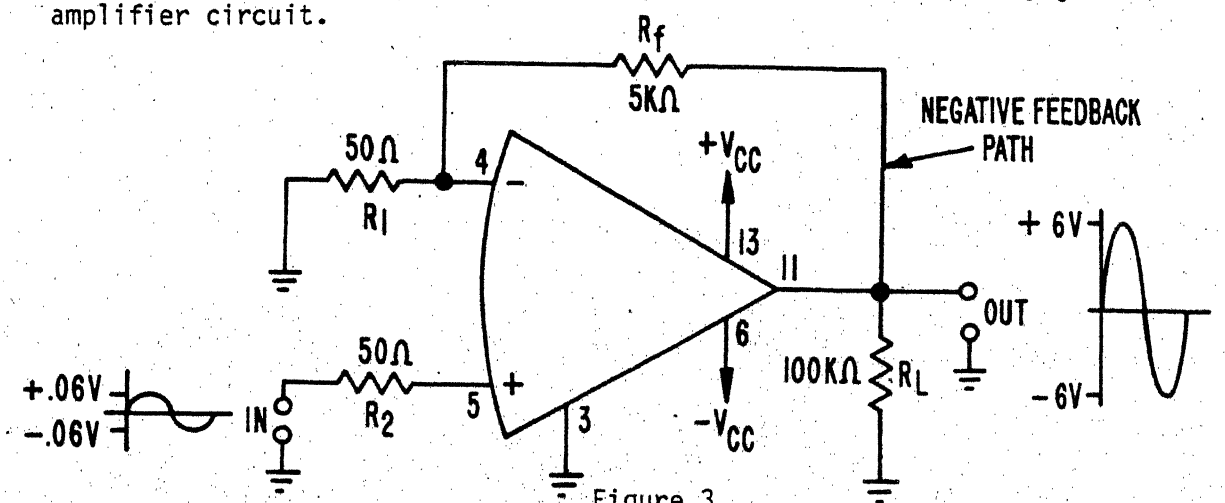


Figure 3

NON-INVERTING OPAMP

This circuit is the same as the inverting amplifier circuit except that the input and bias connections are reversed. Now the input resistor is R2 and the bias resistor is R1.

Operational amplifiers have extremely high gain. Both the inverting and the non-inverting IC opamp amplifier circuits use negative feedback to stabilize the output signal and prevent oscillation. The inverting amplifier has a feedback signal that is 180° out of phase with the input signal and, since both signals are applied to the same point, negative feedback is directly provided. See Figure 4.

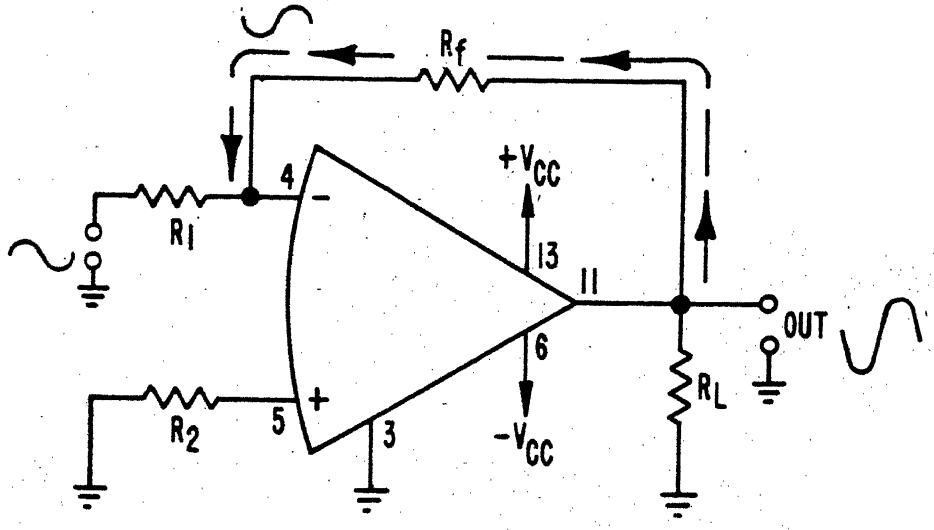


Figure 4

INVERTING IC OPAMP FEEDBACK PATH

The non-inverting amplifier has a feedback signal that is in phase with the input signal which would indicate the use of positive feedback. However, the feedback signal is applied to the inverting input where it is inverted inside the IC. See Figure 5.

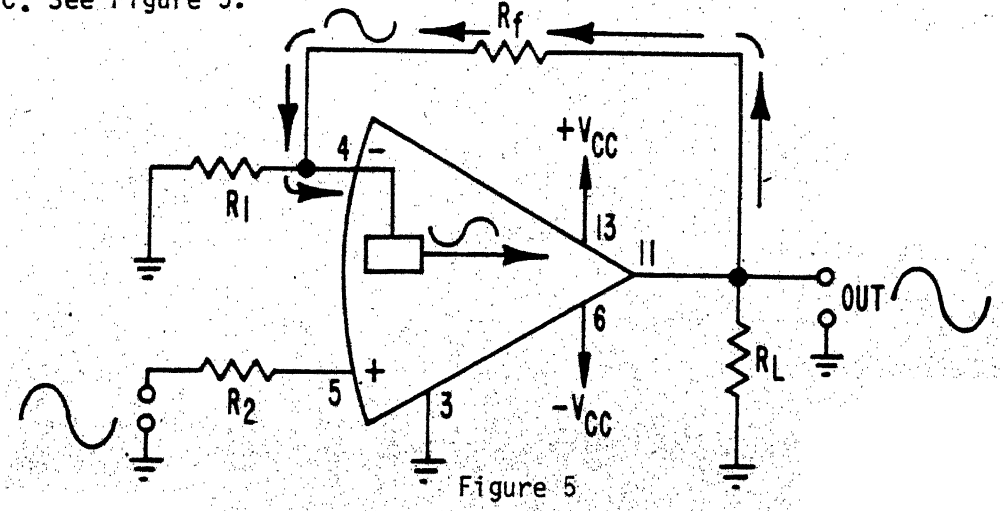


Figure 5

NON-INVERTING IC OPAMP FEEDBACK PATH

The feedback signal on the inverting input terminal (-) acts in opposition to the input signal on the non-inverting terminal (+).

Since the inverted feedback is 180° out-of-phase with the input signal, negative feedback is being used.

To measure the input signal you would use an oscilloscope. But, you must not measure the input signal on the input pin of the IC.

With the inverting amplifier, the negative feedback and the input signal are applied to the IC's input. Since the two signals are 180° out-of-phase, the resultant signal is too small to measure.

With the non-inverting amplifier, the input signal at the IC's input may be smaller than the actual input signal due to the voltage drop across the input resistor.

Therefore you must measure the input signal to either amplifier (inverting or non-inverting) at the points indicated in Figure 6.

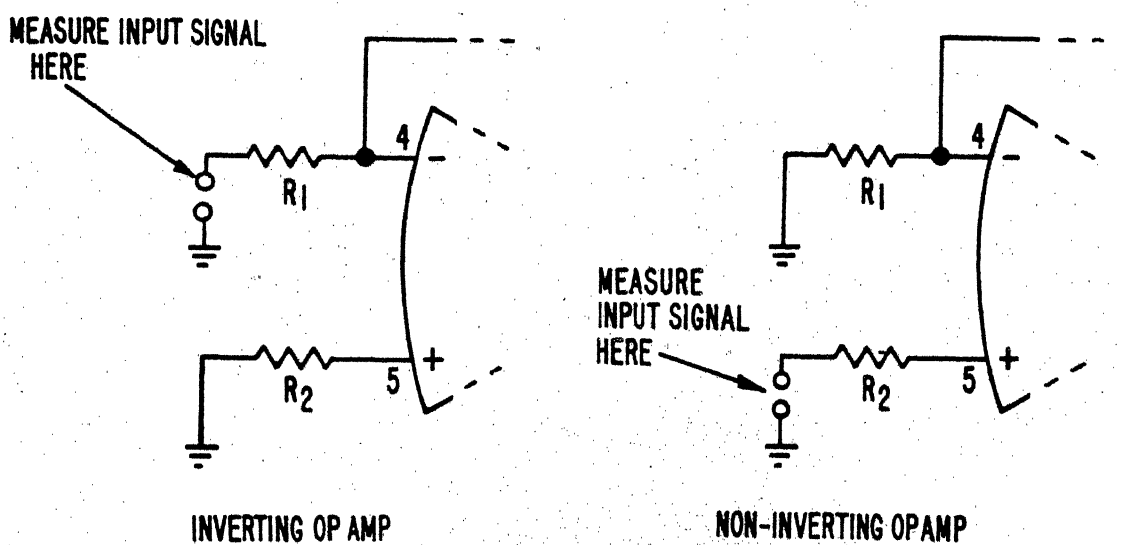


Figure 6

MEASURING OP AMP INPUT SIGNALS

In both the inverting and non-inverting amplifiers, the gain is controlled by the ratio of Rfeedback to Rin or

$$\text{Gain} \simeq \frac{R_{feedback}}{R_{in}}$$

The symbol "$\simeq$" means "approximately equal to". This gain is approximate because there are other factors at an engineering level to take into consideration. However, the gain determined by this formula will be close enough to the actual amount for our purposes.

Since the gain of an amplifier is the number of times the input signal is multiplied,

$$Vout \simeq Vin \frac{Rfeedback}{Rin}$$

(NOTE: This formula may be used regardless of how the input is stated, i.e., peak-to-peak, peak, or RMS. However, the output must be stated in the same terms).

The Vout formula is a good troubleshooting aid. With it you can determine whether the output signal has the correct amplitude or not.

You cannot normally test the IC when the amplifier circuit has a bad output signal. However, you can check the supply voltages to the IC and the components external to the IC.

To check supply voltages to the IC, a VOM or VTVM may be used. The IC opamp requires both positive (+VCC or V+) and negative (-VCC or V-) voltages, most commonly between 6 volts and 18 volts. See Figures 4 and 5. The equipment manuals will indicate the correct voltages and the pin numbers where the voltages are applied.

To check resistance of the external components, a VOM may be used. However, multiple current paths through the IC will cause false readings across the external components. Also, the IC can be damaged by the current from the meter; therefore, the IC must be isolated from the components under test. If the IC is plugged into an IC socket, observing proper handling precautions, unplug the IC. If the IC is soldered into the circuit board, you must unsolder and lift out one lead of the component under test to isolate that component from the IC and other circuit components. Therefore, you should have some idea of the possible cause of a symptom to eliminate unnecessary soldering.

To check the output signal of the IC, an oscilloscope is used. Place the oscilloscope probe on the output pin of the IC. The Vout formula will help you determine if the signal amplitude is correct. Remember, when you check the IC opamp amplifier circuit, you must first check the signal input, the DC voltage inputs, and all external components before considering the IC to be faulty.

IC handling precautions are identical with those for MOS devices and are shown in Figure 7.

NOTICE

SPECIAL HANDLING OF MOS DEVICES

The MOS metal oxide semiconductor devices have a fairly high input resistance making them subject to damage from charges of static electricity through improper handling. The thin layer of oxide can be damaged from discharges of static electricity or improper handling in or out of circuit. The damage may be apparent immediately or may show up only after a short operating time. To avoid possible damage, the following procedures should be followed when handling or testing these devices.

1. The use of synthetic clothing such as nylon should be avoided as this will generate static charges. Dry weather (relative humidity less than 30%) also tends to increase static buildup.

2. Keep the leads of the device in contact with a conducting material or shorted, except when testing, inserting or removing from the circuit.

3. A wrist strap with a megohm resistor in series to common ground should be worn by the technician when inserting, removing or testing MOS devices.

4. Do not remove or insert an MOS device with the power to the circuit or test instrument "ON".

5. Do not apply or inject test signals into the circuit when an MOS device is used with the circuit power "OFF".

6. Do not turn the circuit power "ON" with an MOS device removed from the circuit. Charges can build up causing possible damage when the device is replaced in the circuit.

7. Soldering iron tips, metal bench tops, test equipment and tools should be grounded to a common ground along with the chassis of the set being serviced.

8. Soldering guns should not be used in MOS circuits; AC line leakage from the gun tip could cause damage to an MOS device.

9. Do not apply heat for longer than 10 seconds or closer than 1/16 of an inch to any MOS device when soldering. Use of a heat sink is recommended to prevent damage to the advice.

10. Use the lowest wattage soldering iron possible when removing or inserting MOS devices on printed circuit boards.

Figure 7

IC HANDLING PRECAUTIONS

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, YOU MAY TAKE THE LESSON TEST. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULT WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK
LESSON 2

IC Operational Amplifiers

1. An IC opamp operates class

   a. A
   b. AB
   c. B
   d. C

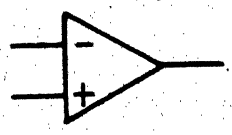
2. An IC opamp is a/an

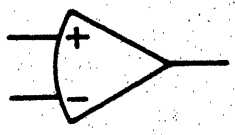
   a. frequency multiplier.
   b. oscillator.
   c. amplifier.
   d. frequency divider.

3. An IC opamp's two inputs (inverting or non-inverting) produce _____ amplifier output(s).

   a. 1
   b. 2
   c. 3
   d. 4

4. The schematic symbol(s) for an IC opamp is/are

   a. 

   b. 

   c. 

   d. either a or b.

5. The gain formula for an IC opamp is Gain = _____.

   a. $\frac{Rin}{Rfeedback}$

   b. $\frac{Rfeedback}{RL}$

   c. $\frac{Rfeedback}{Rin}$

   d. $\frac{Rin}{RL}$

6. The formula for the output voltage of an IC opamp amplifier circuit is Vout = _____.

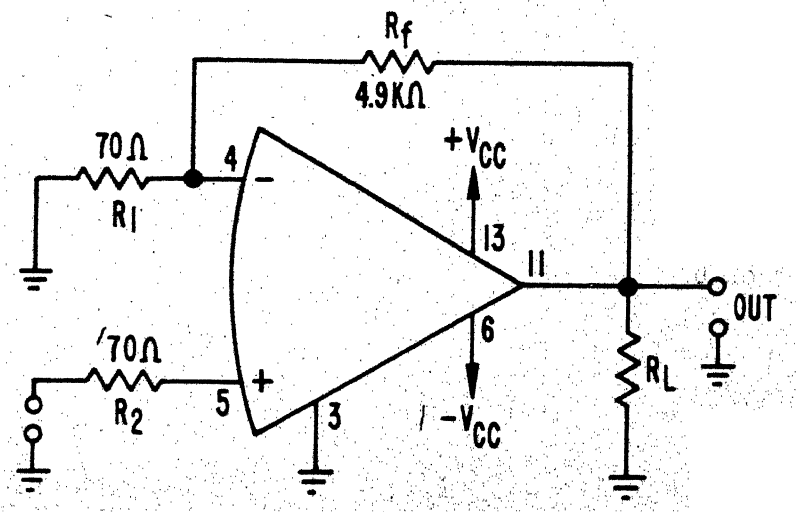
   a. $Vin \left(\frac{Rin}{Rfeedback}\right)$

   b. $Vin \left(\frac{Rfeedback}{Rin}\right)$

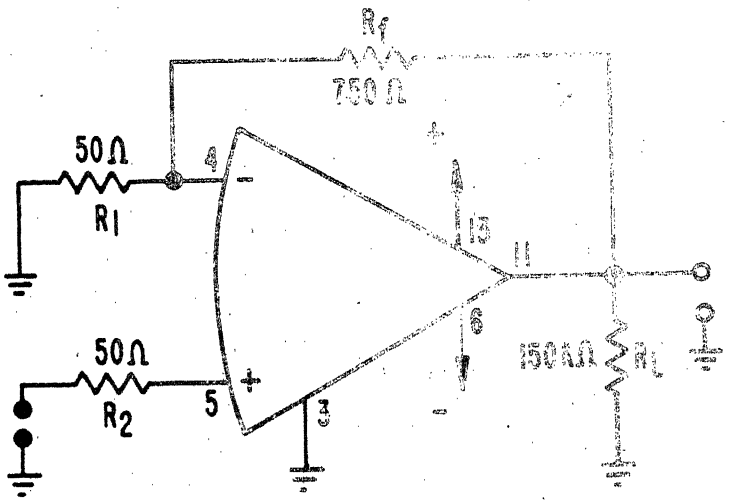
   c. $\left(\frac{\frac{Rfeedback}{Rin}}{Vin}\right)$

   d. $\left(\frac{Vin}{\frac{Rfeedback}{Rin}}\right)$

7. The gain of the circuit below is



8. In the circuit below, with a .06 volt signal applied, the output signal would be _____ volts.



a. 004
b. 15
c. .67
d. .9

9. Both IC amplifier circuit configurations use _____ feedback.

a. negative
b. positive
c. neutral
d. regenerative

10. To check the input signal to an IC opamp circuit you (would/would not) put the oscilloscope probe on the IC's input pin.

11. The power supply required by an IC opamp is a/an _____ voltage.

a. positive D.C.
b. negative D.C.
c. AC
d. both a and b

12. To make resistance checks of the external components of an IC opamp, the IC must be (isolated/in the circuit).

13. For the IC to be considered faulty in an IC opamp circuit, which condition(s) would check good?

    a. The input signal.
    b. The resistance of the external components.
    c. The IC's DC supply voltages.
    d. a, b, and c.

CHECK YOUR RESPONSES TO THIS PROGRAM CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE LESSON TEST. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGE, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

ANSWER SHEET FOR

PROGRESS CHECK

LESSON 2

IC Operational Amplifiers

QUESTION No.	CORRECT ANSWER
1.	a.
2.	c.
3.	a.
4.	d.
5.	c.
6.	b.
7.	a.
8.	d.
9.	a.
10.	would not
11.	d.
12.	isolated
13.	d.

NOTES

NOTES